W. Clark) to give definite lectures upon animal morphology, at first in conjunction with Mr., now Prof. Milnes Marshall, but after two terms, by himself. From that time up to last Christmas his labours were enormous, and his energy untiring. His class grew rapidly in numbers; he had to separate the students into an elementary and advanced division, each with separate lectures, and courses of practical instruction; and though he soon gained the able assistance of Mr. Adam Sedgwick and others as demonstrators, all his pupils enjoyed the priceless advantages of close personal contact with himself. At the same time he carried on, either by himself, or through his pupils, a large number of independent investigations into various problems of embryology and morphology, and set himself to write that great work on "Comparative Embryology," every page, and indeed every line of which is marked at once by the widest knowledge and the clearest insight, and which will tell men in long years to come how great is our loss to day. And all the while he was most active in university and college matters; every syndicate almost was desirous to secure his services, and in the framing of the new statutes of Trinity College he took among the junior fellows a prominent part.

During all these exertions his friends, and I not less than any of them, watched him with anxious care. But he was wise as well as zealous, and never went too far; and when, the second volume of the big book being off his hands, he started last Christmas for a holiday to Messina, the prospects of his health seemed to me better than ever. On his journey outward, he found one of his pupils who had gone to study at Naples laid up with typhoid fever at Capri, and with characteristic kindness he halted to nurse the patient till friends could arrive from England. On his return home, he himself was struck down by an attack of the same fever, which at first threatened to be severe, but happily proved otherwise, and speedily left him; and soon after there came an event which was to him one of the greatest pleasures of his short life.

His fame was now spreading rapidly wherever science reaches, and honours were coming thick upon him. In 1878 he was elected Fellow of the Royal Society, and in 1881 was not only placed on the Council, but received the high distinction of a Royal Medal. In the same year the University of Glasgow conferred on him the degree of LL.D., the British Association, at the York meeting, chose him as one of the General Secretaries, in December last a brilliant company assembled at Cambridge to greet him as President of the Cambridge Philosophical Society, and while he was on his sick bed, the Committee of the Athenæum elected him, as a distinguished man of science, a Member of that Club. Moreover, other Universities were eager, if possible, to win him for themselves. I believe it is no secret that many efforts were made to induce him to become the successor at Oxford of the lamented Rolleston; and it is certainly no secret that the Government again and again pressed him to take the chair of Natural History at Edinburgh. He, however, remained faithful to his Alma Mater, and though, owing to difficulties arising out of impending changes, his merit, in spite of the esteem and pride with which all men at Cambridge regarded him, remained without adequate recognition in his own University, he chose to remain with us, waiting till the future should bring him his dues.

Happily a special effort disclosed the fact that the difficulties were, after all, not unsurmountable; and at last, this spring, with the approbation, I believe, of the whole University, scientific or otherwise, and certainly to the great joy of his friends, a special chair of Animal Morphology was created for him, and he was placed in it.

With this recognition of his worth, which he, I believe, valued beyond even his weightier honours, with the prospect of the increased facilities which the new statutes would give in the coming session, and with his health becoming rapidly restored (for since his fever he had nursed himself, doing but little work, or what to him was little), all the future seemed brighter than it had ever seemed as yet. And when in early July I parted with him, and heard him promise that on those perilous Alpine tracks, he, remembering his past illness, would try nothing rash or likely to strain his powers, I looked forward to meeting him again, both of us perhaps fuller of hopes and plans than we had ever been before.

Of the details of his death, at the moment of writing, we as yet know very little, save that some fatal slip on the glacier of Fresney, above Courmayeur, hurried him and his guide to an instantaneous death.

And now comes the hardest part of my task. The world of science knew Francis Balfour as an investigator of the brightest promise, who, indeed, as a mere youth, had already solved morphological problems which had heretofore baffled the acutest minds, and of whom it seemed difficult to say how far he might not reach. A smaller circle in this country and in Europe knew him also as a man whose firm will and rapid but clear judgment were all the more effective, because his decisions and resolves were made known to others with a winning courtesy and with a kindly sensitive regard for the feelings of those from whom he might differ in opinion. But only those who had the privilege to be his friends knew his real worth, for they alone were aware how much the light of his personal character outshone even his scientific achievements and his administrative powers. It will need great knowledge and skill on the part of him who attempts to show exactly how much science owes to Francis Balfour as an inquirer, a teacher, and a counsellor; but that will be an easy task compared with the effort to tell to those who did not know him what he really was. Workers in biology all the world over will feel that a light has gone from the world when they hear the sad news that he is dead, Cambridge men who have watched events at Cambridge during the last ten years will know that a wholly irreparable loss has fallen upon their University, but their grief and their loss is a small thing put by the side of the emptiness which is left for them whose daily life was brightened by the light of his countenance. These mourn for Lycidas, and cannot be comforted.

M. FOSTER

THE MOUNT WHITNEY EXPEDITION

EXPERIMENTS at the Alleghany Observatory in 1879 and 1880, upon the selective absorption of the solar rays by the earth's atmosphere, having made it probable that the amount of heat the sun sends us (the

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solar constant) had been under-estimated by the methods of previous observers, and that conclusions of importance connected with the temperature of the planet remained to be drawn, it became desirable to verify these results, obtained near the sea-level, by direct simultaneous observations at the base and summit of a very high mountain.

The generosity of a citizen of Pittsburg had provided the special apparatus devised for the new methods, but this was too elaborate to be easily moved to a distant and elevated station. Upon the bearing of the contemplated observations on practical problems of meteorology becoming known to Gen. W. B. Hazen, the Head of the U.S. Signal Service, he kindly offered to facilitate the transportation of an expedition from the Alleghany Observatory to the Western Territories; for no wholly suitable site presented itself, save in regions where the aid of the army might be desirable both for transportation and escort.

With the consent of the trustees of this Observatory, the offer was gladly accepted, and the expedition, which, as originally planned, was a private one, proceeded with material aid from the Signal Service; and under the advantage of Gen. Hazen's official direction I am enabled, by his kind permission, to here briefly indicate its main objects and results, in advance of a full publication of them, which will shortly be made.

The site selected, on the suggestion of Mr. Clarence King, and after conference with officers of the Army and Coast Survey familiar with the western wilderness, as suited to the special observations (which made both great altitude and great dryness desirable), was Mount Whitney in the Sierra Nevada of Southern California. It rises to nearly the height of Mont Blanc from one of the most arid regions in the world, and so abruptly, that two stations can be found within easy signalling distance, whose difference of elevation is over 11,000 feet. It is, however, on the other side of the continent, in an imperfectly explored region, and as very little was known of the possibility of carrying such apparatus as ours to the summit, a military escort was provided, on the contingency of our being obliged to occupy some site still more remote from civilisation.

The scientific members of the party, consisting of Capt. O. E. Michaelis, of the Ordnance, of Messrs. J. E. Keeler and W. C. Day, civilian assistants, and the writer, started from Pittsburg on July 7, for a railroad journey of over 3000 miles, which was greatly facilitated by the courtesy of Mr. F. Thomson, of the Pennsylvania Company, which enabled the writer to take all the apparatus with him in a special car. At San Francisco, after some delay, which the kindness of General M'Dowell, commanding the department of the Pacific, enabled us to pass agreeably, the escort was provided, and the party joined by Mr. George Davidson and two Signal Service non-commissioned officers. With these it proceeded to a point about 400 miles further south (Caliente), where we exchanged the swift motion and the comforts of the Pullman car, for the sharp contrast of a route which commenced (with the shade thermometer registering 110° F.) by a slow journey across the Inyo Desert, shadeless and waterless, for one hundred and twenty miles. We reached, at the close of the month, Lone Pine at the foot of the Sierras, where a camp was made, to be occupied as a lower station, and where the instruments were set up. Among these was a massive siderostat, sending a horizontal beam to a specially constructed spectrometer, an instrument larger than the one which usually bears the name, and in which the eye is replaced by a bolometer, so adjusted as to measure the heat separately in any ray of the visible and the invisible spectrum. When these measures are repeated at an altitude so great that the total atmospheric absorption is markedly different, we are enabled to determine the rate of this absorption for each ray, and, inferentially, to place the observer wholly outside our atmosphere, and to reconstruct the whole spectrum with the hitherto unknown distribution of energy which must exist there. This was used in connection with actinometers, pyrheliometers, and the usual instruments for such a research; but the problem of the safe transportation of the larger apparatus to the summit of Mount Whitney, which now rose above us in a seemingly perpendicular wall of granite, here presented itself in its full difficulty. Our final destination at the summit was in the clearest view, for the extraordinary dryness of the air and the absence of all aërial perspective made the mountain seem so near, that it wore the aspect of a quite neighbouring pile of lofty and moss-covered gray rock, patched with white, and of a wildly jagged outline (the "Sierra"). This white (which we knew to be large snow fields), and the use of the telescope, which resolved the "moss" into great forests, dispelled the illusion, and we realised the obstacles we had to surmount. A preliminary exploration showed that the ascent was difficult, and with such apparatus as ours impossible; a long detour was therefore necessary to avoid the precipices on the eastern front, and our mule trains were in fact occupied from seven to eight days in reaching a point below the summit actually but sixteen miles distant. We traversed in the ascent a trackless wilderness, climbing what seemed utterly impracticable stony heights; down which, once or twice a mule lost his footing and rolled with his scientific freight, but over which, though by such a way as siderostats and telescopes probably never travelled before, all finally passed with a degree of safety beyond our hopes.

We had come here to determine (among other objects) what part of the surface temperature of the planet was due to the sun's direct radiant heat, and what part to the effect of the earth's atmosphere in storing this heat.

It was interesting then, if not wholly agreeable, to repeat the experience of former observers in our own persons, and to notice that as we ascended and the air grew colder, the sun grew hotter, till our faces and hands, browned as they already were by weeks of sunshine below, were burned anew, and far more in the cold than in the desert heat. As we still slowly ascended, and the surface-temperature of the soil fell to the freezing-point, the solar radiation became intenser, and many of the party presented an appearance as of severe burns from an actual fire, while near the summit the temperature in a copper vessel, over which was laid two sheets of plain window glass, rose above the boiling-point, and it was certain that we could boil water by the direct solar rays in such a vessel among the snow-fields.

It is possibly worth remark that owing to the dryness of the air, though isolated snow-fields lay above and below us, the ground we travelled over was bare, and it

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could not be asserted (as it has been of cases at like altitudes in the Alps), that reflection from the snow had anything to do with the state of our very literally "burned" faces.

In view of the lateness of the season it was decided to make the permanent camp at an altitude of rather less than 13,000 feet, rather than wait and make a road to the peak, which rose 2000 feet above us, and was daily climbed for observations with portable instruments.

The sky was perpetually fine, of a deeper violet than I have observed elsewhere, even on Etna, and the dryness extreme, though water from the snow-fields above was abundant. An equatorial telescope of 5½ inches aperture, which was kindly loaned by Prof. E. C. Pickering, it was found too late could not be well used to determine the quantity of the "seeing," owing to a maladjustment of the eye-pieces, which it was necessary to hold in the hand. Under these circumstances a critical estimate of the definition under high powers could not be made, but enough was seen to make it evident that it was generally excellent, and that such a site possessed advantages for an astronomical, as well as for a meteorological station.

It is greatly to be desired that it should be occupied, with the protection of a permanent building, adapted to either object, and it is probable that such provision will be hereafter made.

For us, however, there was no other shelter than our tents, and the high wind, the cold, and the mountain sickness consequent on the rarefied air, made the continuous observations which were kept up synchronously with that at the camp at Lone Pine, a matter of difficulty. These observations were persistently maintained, however, but we were not sorry on September 11 to break up our wintry camp and to descend to summer again. We resumed our journey across the desert, and then across the continent, reaching Pittsburgh on September 28, 1881.

The reductions of the observations are still incomplete, but some conclusions of interest may already be indicated.

It has been said that the determination of the amount of heat the sun sends the earth is the fundamental problem of meteorology, since on this all the phenomena which that science contemplates depend. Accordingly the observations were directed first to this primary object, chiefly through methods which involved the study of the phenomena of selective absorption (so intimately connected with it), and secondarily to these phenomena considered in themselves.

The final result may be affected by some still imperfectly determined corrections, and it will be sufficient to here give an approximative one.

It appears probable that the true solar constant is one-half greater than that determined by Pouillet and by Herschel near the sea level, and even greater than the recent values assigned by M. Violle. The true value, it is believed, will be shown by the data when published to be larger than those hitherto accepted.

Of more general interest, perhaps, is the conclusion as to the limit of that cold which increases under full sunshine as we ascend above our atmosphere. "What," it may be asked, "would the temperature of the soil be on a mountain top rising wholly above the air, or what the temperature of the sunward hemisphere of the earth, if the present absorbing atmosphere were wholly withdrawn?" The personal experiences already alluded to may prepare the general reader for the paradoxical result that if this atmosphere were withdrawn, the temperature would greatly fall, though under a materially greater radiant heat.

The student of the subject is aware that this conclusion follows from the fact that the loss by radiation into space as the atmosphere is withdrawn is much more rapid than the gain by direct solar heat, but even he may not perhaps be prepared for the extent of the fall.

The original observations, which will be given at length, lead, in the writer's opinion, to the conclusion that in the absence of an atmosphere the earth's temperature of insolation would at any rate fall below $-50°$ F., by which it is meant that (for instance) mercury would remain a solid under the vertical rays of a tropical sun were radiation into space wholly unchecked, or even if the atmosphere existing, it let radiations of all wave-lengths pass out as easily as they come in. Remembering, then, that it is not merely by the absorption of our air, but by the selective quality of this absorption, that the actual surface temperature of our planet is maintained, we see that without this comparatively little-known function, it appears doubtful whether, even though the air supported respiration and combustion as now, life could be maintained upon this planet.

These conclusions do not, in the writer's opinion, depend upon the Mount Whitney observations alone, but exist implicitly in the results of previous observers who have, however, not apparently drawn them, with the exception, perhaps, of Mr. Ericsson, who has observed that the surface of the airless moon must remain cold even in sunshine.

We see, if these results be true, that the temperature of a planet may, and not improbably does, depend far less upon its neighbourhood to, or remoteness from, the sun, than upon the constitution of its gaseous envelope, and indeed it is hardly too much to say that we might approximately indicate already the constitution of an atmosphere which would make Mercury a colder planet than the earth, or Neptune as warm and habitable a one.

It must at the same time be admitted that our information as to the special constituents of our own air, which are chiefly here concerned, is still imperfect, though the observations made at Mount Whitney upon the selective action of that undoubtly prominent agent, water-vapour, will, it is hoped, add somewhat to our knowledge.

In the same connection it may be added that the writer's investigations have led him to the conclusion that the "temperature of space," so called, must at any rate be lower than that assigned by Pouillet (if we accept the received values for that of the absolute zero), and in this case the temperature of the earth's surface, in the absence of the quality of selective absorption in our air, would be yet lower than that here given.

In view of the great importance of this quality, interest will attach to the statement that the bolometer observations at the summit and base of Whitney show a different distribution of solar energy (heat, light, or "actinism") at the upper station from that at the lower, and show (among other things) that without our atmosphere, the

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sun would appear of a strongly bluish tint, thus confirming observations already made at Alleghany by other methods. It may be added in this connection that researches also there made show a like action in the solar atmosphere, so that we are not only to understand that there is a tendency in both atmospheres to absorb the short waves more than the long ones (as the writer has elsewhere stated), but that the solar photosphere (while emitting radiations of all wave-lengths in greater quantity than we receive them), is, through the immense preponderance of the more refrangible rays before absorption, essentially blue, and that white light is *not* "the sum of all radiations," nor even of all visually recognisable ones, but a composition of the small groups of special rays, which, starting from this essentially blue sun, by virtue of their large co-efficients of transmission, and by a kind of survival of the fittest, have struggled through the solar and terrestrial atmospheres, to us, while others of short wave-length have failed on the way. This the Mount Whitney observations, so far as regards the terrestrial atmosphere at any rate, appear to prove.

Doubtless a distinction is to be drawn between the statements of fact and records of direct observation, which will shortly appear in full in the Signal Service publication, and the present inferences from them, for which the writer alone should be held responsible.

In view of the mass of observations on which they rest, and the writer's endeavour to avoid any statement which does not seem to him to express the result of careful and repeated experiments, he hopes, however, that the results to be given in the forthcoming volume will be found to bear out these conclusions, and prove useful contributions from the younger science of solar, to the elder one of terrestrial meteorology.

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July 13, 1882

ASIA

Asia. By A. H. Keane. Edited by Sir R. Temple. (London: Edw. Stanford, 1882.)

MR. KEANE'S encyclopædic knowledge in matters of philology and ethnology was never put to better use than in the compilation of this account of Asia. Considerable as is the size of the book, the information it contains is compressed to the utmost; every word is pregnant with meaning, and could not be omitted without injury to the reader. The physical geography, the fauna and flora, the commerce and inhabitants of the vast continent of Asia, are all passed under review; tribes and dialects of which most of us have never even heard the names are discoursed upon familiarly, and facts and statistics bristle in every page. The latest authorities have been everywhere consulted; the geographical results of the late Afghan war, for instance, having been laid under contribution, and full use being made of the Palestine Exploration Survey, not only of Palestine itself but of the eastern side of the Jordan as well. It must not be supposed, however, that Mr. Keane's work is dry reading; his literary ability has thrown an interest over the most matter-of-fact statistics and made us realise the characteristics of the countries he describes or the towns and populations he records.

I need not point out the value to the Englishman of a full and trustworthy compendium like this. As Sir Richard Temple shows in his Preface to the book the interests of England in Asia are enormous, and there is much truth in the German assertion that so far as English power and *prestige* are concerned we are no longer Great Britain but Great India. But it is not only in India that English influence is supreme; our dependencies extend as far as Hongkong, and our trade with Japan amounted in 1880 to over five millions of imports alone. To the student of mankind the interest of Asia is greater than that of any of the other continents of the world. Here was the first home of the races who have chiefly influenced the course of human progress; here the early civilisations of Accad, of China, and of Phœnicia grew up and developed; here the great empires of antiquity rose one upon the other; and here was the primæval source of those germs of thought and art that have produced the philosophies, the sciences, and the arts of our own day. It is among the multitudinous tribes and nations of Asia, too, that we can best study that variety of languages, of manners, and of customs which have enabled the modern inquirer to lift a little the veil that covers the first beginnings of civilisation, and there are even some who believe that the great central plateau of Tibet before it was raised to its present elevation was the primæval cradle of mankind, the spot where the anthropoid ape became the still speechless man. It is possible that our young and therefore arrogant western civilisation has yet much to learn from the old culture of the east, and it is a question whether Sir R. Temple is justified in saying that the Chinese are "implacably hostile to real progress" because they hate "modern (European) progress." At all events the example of Japan is not encouraging.

It is a great pity that Mr. Keane's alphabetical list of the races and languages of Asia had to be sacrificed to the exigencies of space. The room now occupied by a number of very useless woodcuts could well have been given up to it. We must be thankful, however, for the Ethnological and Philological Appendix which he has added at the end. In this he sums up in a clear and trenchant manner the chief facts at present known about the ethnology of Asia. He pertinently points out the great distinction that exists between the different types of race and language we find there. "All races are fertile with one another, though perhaps in different degrees," whereas the stock-languages of the continent "are true species which refuse to amalgamate and thus form new species, so that fresh varieties are developed only within each" of them. The conclusion from this fact seems to me to be that while the different races of mankind may be referred to a single primitive pair, the different families of speech have branched off from independent centres. Mr. Keane, however, still clings to the belief in a single primæval language or type of language, and rejects the hypothesis that man was speechless when the leading races were differentiated from one another. But the argument on which he bases his rejection of the theory is founded on a misconception; language and race are not synonymous terms, and those who hold the doctrine of

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